

BACKGROUNDER:

Digital 1125/60
High Definition TV
Production
Standard
SMPTE 260M

0010001	0010101	0010100
1001010	0101010	1010011
0011100	1125/60	1001010
1010101	1111010	0101110
0100100	1010010	1010010
0101010	1001001	1000100
1010000	1001010	0111101
1011110	0010101	1101010
1100101	0100101	1010010
0010010	0111010	1125/60
1001001	1010101	1010010
0010010	0101000	1001010
1001011	1110101	0101001
1001001	0101010	0101001
0010100	1110101	0100100
1125/60	0101010	1001001
1001010	1010101	0010010
1010101	1011101	1010101
0101110	0101101	0110101
1010010	0010001	0001001
1001010	0000100	0010101
0111101	1125/60	0101010
1101010	1001010	0101000
1010010	0011100	1111010
1010010	1010101	1010010
1001010	0100100	1001001
0101001	0101010	0100101
0101001	1010000	0010101
0100100	1011110	0100101
1001001	1100101	0111010
1125/60	0100100	1010101
0010010	1001001	1001010
1001010	0010010	1110101
0110101	1001011	0101010
0001001	1001001	1110101

HDV
1125/60
GROUP



In recent years a significant advance took place in the United States. Following some years of extensive and diverse research and development within major labs directed at the highly challenging task of developing an encoding/modulation system to allow HDTV transmission over a standard 6 MHz terrestrial broadcasting channel, dramatic breakthroughs have recently emerged.

The proposal by General Instruments (GI) in the summer of 1990 for an all-digital HDTV transmission system was quickly followed by revelations of similar advances elsewhere. Today, four separate approaches to all-digital HDTV terrestrial transmission are being examined by the FCC Advisory Committee on Advanced Television Services. The United States has stepped forward in dramatic fashion as a world pioneer in digital broadcasting technology.

The relatively sudden heightening of overall interest in a digital transmission system immediately raises the question

of a suitable digital HDTV production signal format to feed a possible digital over-the-air encoder/modulator. Accompanying such a question is the attendant scrutiny of the many years of work that might already have been invested in an "analog" HDTV production standard. Is this work suddenly made obsolete?

Happily, the answer is *not at all*. Here in the United States, work has been directed toward developing an HDTV production standard for the past seven years. An enormous amount of progress has been made with extensive contribution from many sectors of the TV and film industries, and from the program production community.

What is especially important was the clear recognition that an HDTV production standard is not an issue of analog *or* digital — it clearly embraces analog *and* digital considerations. Both aspects were part of the first discussions in 1983 within SMPTE (Society of Motion Picture and Television Engineers) and

ATSC (Advanced Television Systems Committee).

The first HDTV standard that emerged, SMPTE-240M, at first glance reads like an "analog" document describing an analog set of parameters. Indeed, it does just that. This is necessary, because an HDTV production standard should clearly describe all that is associated with the structuring of an electronic signal parameter set, one that results from capturing the analog real world scene by the fundamentally analog process of an HDTV camera (using tubes or CCD imagers). Any HDTV production standard will always necessitate the inclusion of such a description.

However, behind the scenes in developing SMPTE-240M lies a considerable body of digital thinking. As early as 1985, a proposed genesis of a digital representation of this signal was grappled with to aid in the final selection of key "analog" parameters, such as aspect ratio and camera blanking widths. This was sufficient to allow full documenta-

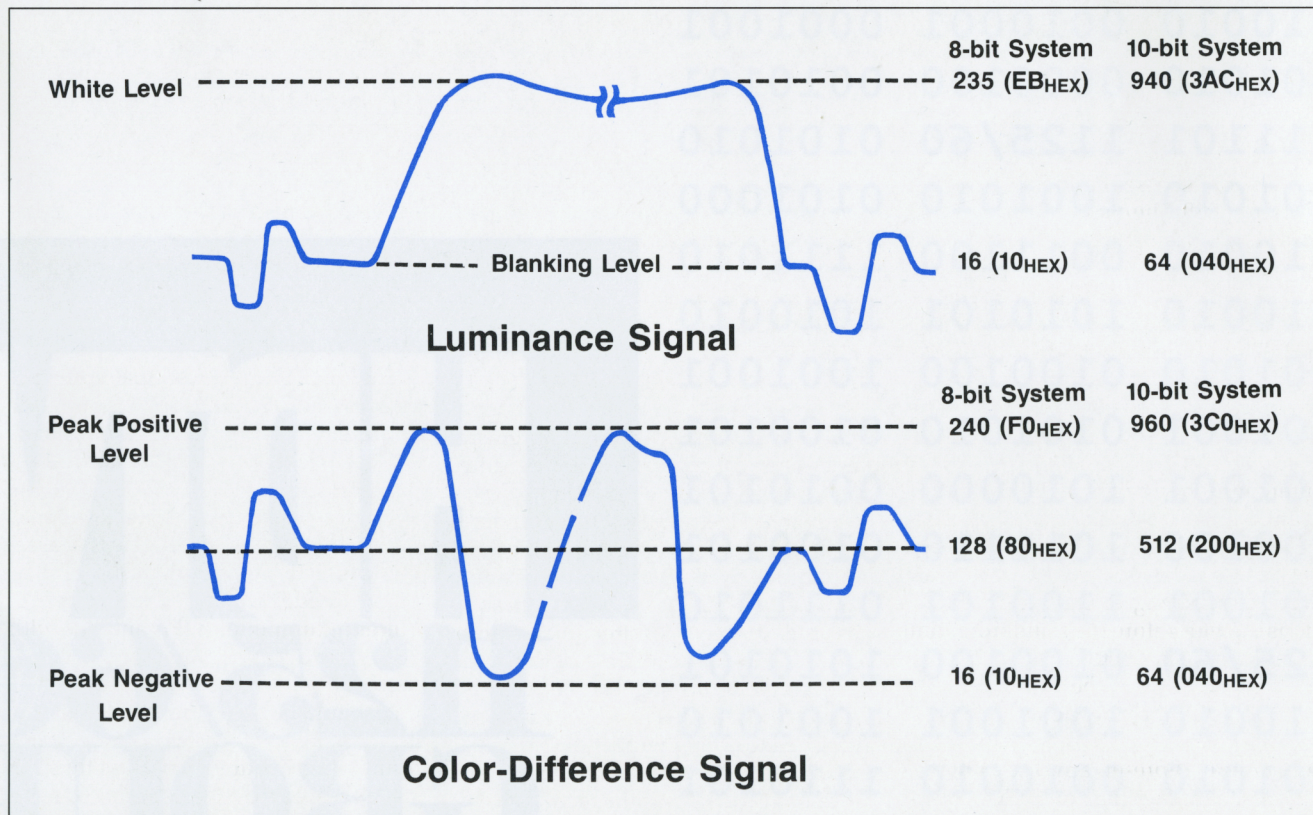


Figure 1. Range of data values for digital 1125/60 HDTV signals.

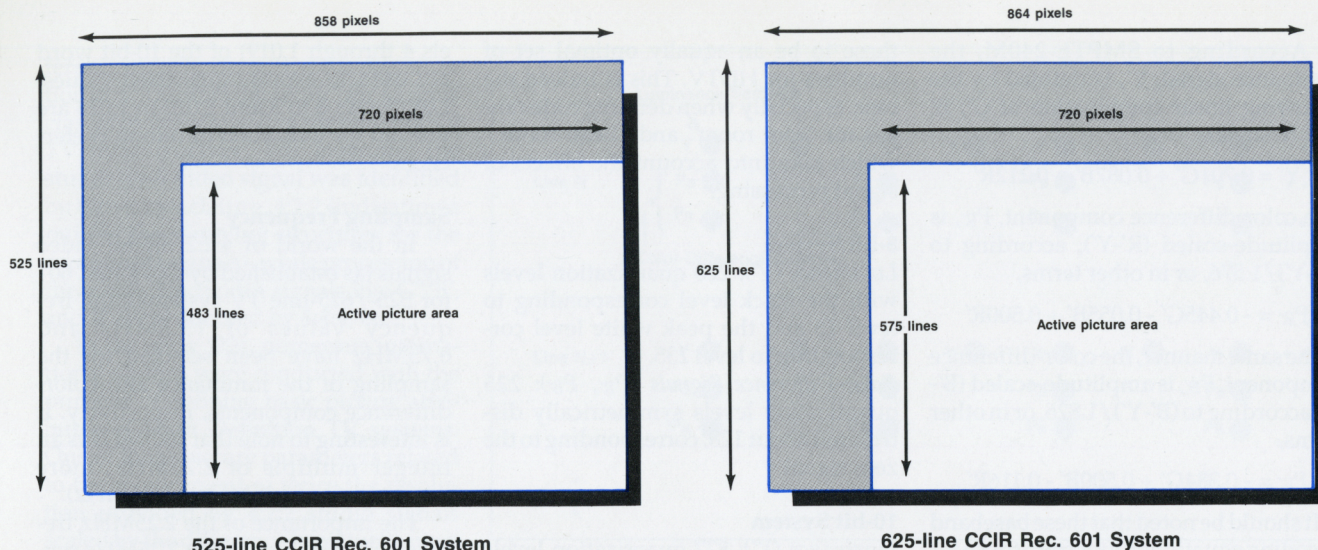


Figure 2a. Pixel count for CCIR Rec. 601 525- and 625 line TV signals.

tion of all basic parameters of the HDTV production signal parameter set — which was standardized by SMPTE in 1988. Work began immediately within a special dedicated SMPTE digital group to build on this standard and study all details for a full digital representation of SMPTE-240M.

THE DIGITAL GAME PLAN

Following the emergence of the SMPTE-240M standard, the rapid and still increasing desire for hardware and software tools for the digital capture, storage, transmission and manipulation of HDTV images in the 1125/60 format created a sense of urgency within the SMPTE Working Group on High Definition Electronic Production (WG-HDEP) toward the completion of the digital characterization of the 1125/60 HDTV signal parameters, SMPTE 260M.

WG-HDEP created an Ad Hoc Group on Digital Representation of 1125/60 in October 1988. The charter of this Ad Hoc Group was to study and document the digital representation of basic 1125/60 HDTV as defined within the body of the SMPTE-240M HDTV production standard. The unified digital description of the 1125/60 HDTV signal was expected to stimulate the development of all-digital equipment and to enhance the development of universal interfaces for the interconnection of digital HDTV equipment from the various manufacturers. Indeed, as SMPTE works moved toward internal consensus, some manufacturers were committing to the recommendations — even before the standardization process was complete.

To fulfill its task, the Ad Hoc Group brought together a large cross-section of industry experts:

- Technical representatives of international manufacturers of HDTV equipment.

- Designers of digital video processing and computer graphics equipment.
- Current users of 4:2:2 digital 525-/625-line equipment.
- Motion picture engineers looking to ensure the highest standards of image quality for motion picture related HDTV imaging.
- Technical members of broadcasting and research organizations.

SPECIFIC AREAS OF DIGITAL STUDIES

The Ad Hoc Group held numerous meetings since its creation. The in-depth discussion that took place during these meetings capitalized on the prior decade of experience with 525-/625-line 4:2:2 digital facilities and resulted in new understandings. These translated into multiple requirements for the SMPTE-240M standard as it applied to various high-resolution video and image processing environments.

Numerous studies and recommendations were painstakingly brought into focus, and a document for the digital representation of, and the design of a bit-parallel digital interface for the 1125/60 studio HDTV standard has now been completed. It is SMPTE 260M.

It is not easy to read standard documents for the first time and fully grasp the complex technical decisions and implications. It is the intention of this document to help the industry understand some of the important work that took place within this committee. Hopefully, this will prepare many interested parties to better understand this recently completed standard that has emerged from SMPTE. Under normal due process, this proposal has been published to gather wide industry comments before the final standardization process of SMPTE was finished.

The following sections describe spe-

cific areas of study within the standardization group:

- digital encoding parameters of the 1125/60 HDTV signal
- dynamic range considerations
- transient regions
- filtering characteristics
- design of the bit-parallel digital interface

ENCODING PARAMETERS

The process of converting analog signals into their digital counterpart is known as "Encoding of the analog signal," and is characterized mainly by the following parameters:

- Specification of Signal Components Sets
- Number of bits per component sample
- Correspondence between digital and analog video values (assignment of quantization levels)
- Sampling frequency
- Sampling structure

The sections below discuss in more detail the studies surrounding the digital encoding parameters of the 1125/60 HDTV signal.

Signal Component Sets

The specification of the analog characteristics of the 1125/60 HDTV signal, as documented in the SMPTE-240M standard, established two sets of HDTV components:

- A set consisting of three full-bandwidth signals, G' , B' , R' , each characterized by a bandwidth of 30MHz.
- A set of luminance, Y' , and color-difference components ($P_{R'}$ and $P_{B'}$) with bandwidths of 30MHz and 15MHz, respectively.

It should be noted that the primed G' , B' , R' , Y' , $P_{R'}$ and $P_{B'}$ signal components result when linear signals pass through the non-linear opto-electronic transfer characteristic of the HDTV camera.

According to SMPTE-240M, the luminance signal, Y' , is defined by the following linear combination of G' , B' and R' signals:

$$Y' = 0.701G' + 0.087B' + 0.212R'$$

The color-difference component, $P_{R'}$, is amplitude-scaled ($R'-Y'$), according to $(R'-Y')/1.576$, or in other terms,

$$P_{R'} = -0.445G' - 0.055B' + 0.500R'$$

In the same manner, the color-difference component, $P_{B'}$, is amplitude-scaled ($B'-Y'$) according to $(B'-Y')/1.826$, or in other terms,

$$P_{B'} = -0.384G' + 0.500B' - 0.116R'$$

It should be noted that these baseband encoding equations differ from those for NTSC (or CCIR Rec. 601) because they relate to a specified SMPTE-240M colorimetry and white point color temperature (i.e., D65).

Bits per Component Sample

The use of 8-bit quantization (CCIR Rec. 601) has become the norm in the digital recording of conventional component and composite TV signals. Today, an 8-bit linear quantization per sample is the practical limit. This limit is determined not only by technical and economic constraints, but also from conclusions reached after objective and subjective testing within SMPTE and EBU in the late '70s and early '80s.

However, increasing demands of the production and post-production community had to handle wider dynamic range signals (particularly for very high quality HDTV to 35mm film transfers) and for multiple generations of signal processing led to the consideration of using 10-bit as well as 8-bit quantization for future generations of digital 1125/60 equipment (see Figure 1). The data below describe the resulting characteristics for 8- and 10-bit systems.

Form of Encoding

The process to convert the 1125/60 HDTV signals into their digital form uses Pulse Code Modulation (PCM). An A/D converter uses a linear quantization law with a coding precision of 8 or 10 bits per sample of the luminance signal and for each color-difference signal.

Correspondence Between Video Signal and Quantization Levels

The encoding characteristics of the 1125/60 HDTV signal follow those specified in Rec. 601 of the CCIR (encoding parameters for 525-/625-line digital TV systems) for use with 8-bit and 10-bit systems. The experience gained over the past decade with 4:2:2 systems showed

these to be an equally optimal set of numbers for HDTV. This is indeed the case, especially when defining code ranges for "foot room" and "head room," which take into account the effects of signal processing.

8-bit System

Luminance (Y'): 220 quantization levels with the black level corresponding to level 16 and the peak white level corresponding to level 235.

Color-Difference Signals ($P_{R'}$, $P_{B'}$): 225 quantization levels symmetrically distributed about 128, corresponding to the zero signal.

10-bit System

Luminance (Y'): 877 quantization levels with the black level corresponding to level 64 and the peak white level corresponding to level 940.

Color-Difference Signals ($P_{R'}$, $P_{B'}$): 897 quantization levels symmetrically distributed about level 512, corresponding to the zero signal.

Quantization Level Assignment

8-bit system

254 of the 256 levels (quantization levels 1 through 254) of the 8-bit word are used to express quantized values. Data levels 0 and 255 are used to indicate timing references.

10-bit System

1,016 of the 1,024 levels (digital lev-

els 4 through 1,019) of the 10-bit word are used to express quantized values. Data levels 0 to 3 and 1,020 to 1,023 are utilized for indication of timing preferences.

Sampling Frequency

In the world of 4:2:2 digital video signals (as established by CCIR Rec. 601 for 525-/625-line TV systems), the frequency values of 13.5MHz and 6.75MHz have been selected for the sampling of the luminance and color-difference components, respectively. It is interesting to note that 13.5MHz is an integer multiple of 2.25MHz, more precisely, $6 \times 2.25\text{MHz} = 13.5\text{MHz}$.

The importance of the 2.25MHz frequency lies in the fact that 2.25MHz represents the minimum frequency found to be a common multiple of the scanning frequencies of 525- and 625-line systems. Hence, by establishing sampling based on an integer multiple of 2.25MHz (in this case, $6 \times 2.25\text{MHz} = 13.5\text{MHz}$), an integer number of samples is guaranteed for the entire duration of the horizontal line in the digital representation of 525- and 625-line component signals (i.e., 858 for the 525-line system and 864 for the 625-line system). More important, however, is the fact that a common number of 720 pixels can now define the active picture time of both TV systems (see Figure 2a).

Also, the sampling frequencies of 13.5MHz, for the luminance component, and 6.75MHz for each of the color-dif-

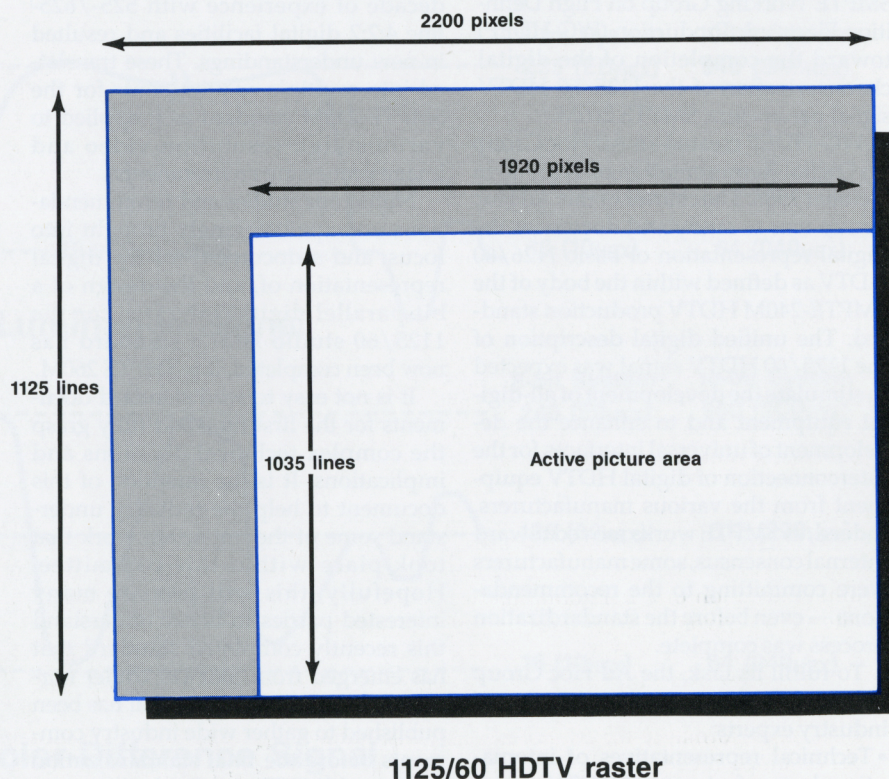


Figure 2b. Pixel count for the 1125/60 HDTV production standard.

ference signals, permitted the specification of a "Digital Hierarchy" for various classes of signals used in the now digital TV infrastructure. For example, the studio level video signal was identified by the nomenclature, 4:2:2 (indicating a ratio of the sampling structures for the component signals), while processing of three full-bandwidth signals like G' , B' , and R' were denoted by 4:4:4, etc.

In the early '80s, numerous international studies were conducted with the purpose of defining basic picture attributes of High Definition TV systems. One of those picture parameters related to the requirement of twice the resolution provided by 4:2:2 studio signals scaled by the difference in picture aspect ratios (that is, between the conventional 4:3 picture aspect ratio and the new 16:9 aspect ratio). The international standards organization CCIR, hence, recommended the number of 1,920 pixels for the active portion of the scanning line. In other words:

$$720 \times 2 \times \frac{(16/9)}{(4/3)} = 1,920$$

The desire to maintain as simple a relation as possible between the sampling frequencies of the 1125/60 HDTV signals and the already established digital world of 4:2:2 components led (back in 1985, at technical meetings within the Advanced Television Systems Committee) to the selection of a sampling frequency that was an integer multiple of 2.25MHz.

The standard sampling frequency value of 74.25MHz is 33 times 2.25MHz. When considering the total horizontal line-time of the 1125/60 HDTV signal of 29.63 μ s, it gives rise to a total number of 2,200 pixels. This number conveniently accommodated the 1,920 pixels, already agreed by the international TV community as the required number of active pixels for HDTV signals.

Other sampling frequencies were considered. Values of 72MHz and 81MHz, among others, were examined, which are also an integer multiple of 2.25MHz. However, lower values of the sampling frequency result in very narrow horizontal retrace intervals for the 1125/60 HDTV signal, if 1,920 pixels are assigned to the active part of the picture. The sampling frequency of 74.25MHz allows, on the other hand, the practical implementation of a horizontal retrace interval (horizontal blanking time) of 3.77 μ s. It should be mentioned that this narrow horizontal blanking interval already represents a tremendous challenge in performance for the horizontal deflection of circuits of 1125/60 HDTV cameras and displays.

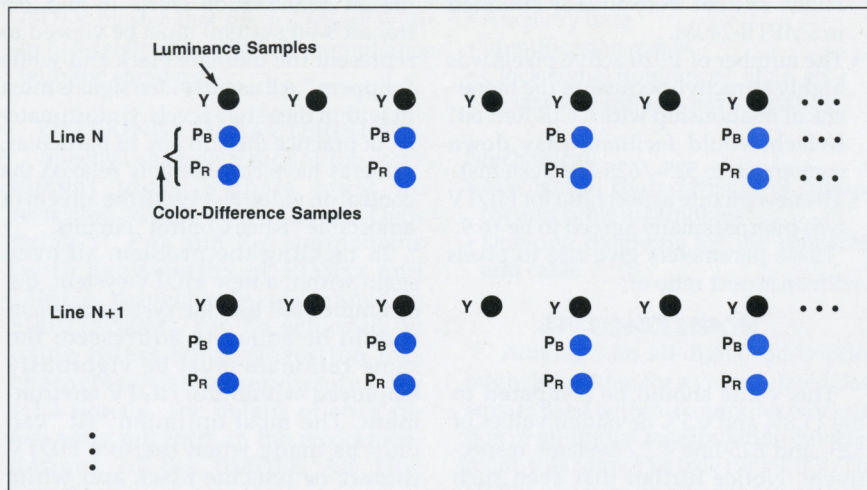


Figure 3. Sampling structure for the 1125/60 HDTV production standard.

this value of 74.25MHz for the sampling frequency is that none of its harmonics interfere with the values of international distress frequencies, i.e., 121.5MHz and 243MHz.

For the case of sampling color-difference components, one-half the value of the sampling frequency for the luminance signal is to be used i.e., 37.125MHz. This gives rise to a number 960 pixels for each of the color-difference components during the active period of the horizontal line and 1,100 for the entire line.

Overall, 74.25MHz emerged as the sampling frequency of choice in the proposal for the 1125/60 HDTV signal set, because it appears to yield the optimum compromise among many related parameters:

- Practical blanking intervals
- Total data rates for digital HDTV VTRs
- Compatibility with signals of the CCIR Rec. 601 digital hierarchy
- Manageable signal processing speeds

In summary, the current standard set of numbers of the 1125/60 HDTV scanning line exhibits the following number of pixels (see Figure 2b):

Signals \ Pixels	Total	Active
G' , B' , R' , Y' (Luminance)	2,200	1,920
P_R' , P_B' Color-Difference	1,100	960

Sampling Structure

The fact that the full-bandwidth components G' , B' , R' , and Y' are sampled using the same sampling frequency of 74.25MHz results in identical sampling structures (locations of the pixels on the image raster) for these signals. Furthermore, because of the integer number of samples per total line, i.e., 2,200, the sampling pattern aligns itself vertically forming a rectangular grid of samples. This is known as an "orthogonal sampling structure" that is line, field and

frame repetitive. This kind of sampling structure facilitates the decomposition of most 2-D and 3-D processing algorithms into simpler operations that can be carried out independently in the horizontal, vertical and temporal directions, and, hence enables the use of less complex, modular hardware and software systems.

Also, the relation between the sampling positions of the luminance and color-difference signals is such that P_B' and P_R' samples are cosited with odd (i.e., 1st, 3rd, 5th, 7th) samples of the luminance component in each line (see Figure 3).

The Issue of Square Pixels

The SMPTE committee spent considerable time examining the merits of a proposal quite new to the TV industry — the square pixel.

Originally proposed by representatives from the graphics industry, the existence of square pixels, i.e., an orthogonal sampling grid with equal horizontal and vertical spacing, although a desirable feature for low-end computer graphics systems (because simple software tools can ease hardware demands for still-image manipulation), need not be required for more complex graphics and image processing terminals.

The latter point has been demonstrated universally in post production settings for quite some time, with the commercial availability of sophisticated computer graphics and special effects generators for 4:2:2 pictures in the 525-/625-line studio component world (which by definition do not have square pixels), and, more recently, showing the same versatility in image manipulation utilizing the 1125/60 HDTV format.

The committee was confronted with the following facts:

- The 1,035 active lines of 1125/60

HDTV system were already specified in SMPTE-240M.

- The number of 1,920 active pixels was highly attractive because of the hierarchical relationship with CCIR Rec. 601 (which would facilitate easy down conversion to 525-/625-line systems).
 - The new picture aspect ratio for HDTV was internationally agreed to be 16:9.
- These parameters give rise to pixels with an aspect ratio of:

$$1920/1035 \times (9/16) = 1.043,$$

This value should be compared to the 11.8% and 6.5% deviation values of 525- and 625-line 4:2:2 systems respectively. Notice further that even such deviations from perfect square pixels do not materially affect the software and hardware calculations that have to be performed when executing special image manipulations, because the scaling factors, in most cases, are incorporated in the numerical factors used in the 2-D and 3-D rendering algorithms.

DYNAMIC RANGE CONSIDERATIONS

As indicated above, the quantization assignment chosen for CCIR Rec. 601 established video signal black at level 16, and nominal white at level 235. These levels leave a small amount of "foot room" and "head room" to cope with inevitable overexcursions introduced by analog and digital processing (ringing introduced by filtering, image manipulations, etc.) common in any real production/post-production environment. However, to ensure a safe system

design quantization levels 16 and 235 (for an 8-bit system) must be viewed to represent the ultimate black and white "clippers." All useful video signals must fit within these two levels. Unfortunately, in practice they do not. In particular, cameras have considerably relaxed the control on video level with the advent of adjustable "Knee Control" circuits.

In tackling the problem all over again within a new HDTV system, the committee felt that the system problem should be squarely addressed: the same rationale must be vigorously employed within the HDTV environment. The most optimum "fit" can only be made when the live HDTV camera or telecine black and white clippers are set to precisely correspond to these two levels. This correspondence is established by the digital HDTV interface standard, 260M, because it ensures the proper correlation between camera final output clipping settings and digital levels 16 and 235. Figure 4 depicts the process.

In view of this rationale, the Ad Hoc Group produced a set of guidelines for the operation of HDTV cameras that will ensure proper digital acquisition of large dynamic range camera output signals (resulting from creative exposure beyond nominal white level in the viewed scene). The following relationship between the camera analog signal values and the quantized representation should be observed:

- An upper level of 700mV and a black level of 0mV should correspond to the absolute maximum (peak-white) and minimum (black level) HDTV signal

levels, respectively.

- The effects of camera highlight processing, such as Knee and Slope characteristics, should be included within the aforementioned range.
- Overshoot/undershoot effects caused by video processing circuitry can exceed the above limits.
- The peak-white level of 700mV should correspond to the quantization level 940 in a 10-bit system or to level 235 in an 8-bit system.
- The black level (0mV) should correspond to level 64 in a 10-bit system or to level 16 in an 8-bit system.

Further studies are necessary to continue the work for the precise description of the camera compression curves ("Knee and Slope") in order to achieve the desired extended exposure capabilities within the 700mV range. These studies are being carried out by another SMPTE Ad Hoc Group on HDTV Production Colorimetry.

TRANSIENT REGIONS

The SMPTE 260M HDTV production standard makes use of a picture aspect ratio of 16:9, with 1,920 pixels per active line by 1,035 lines. However, the digital processing of the HDTV analog signal sometimes produces various forms of "transient effects" that must be taken into account for the proper use of the HDTV studio digital signal within real-world systems. Based on a considerable body of experience with the 4:2:2 digital system, it is now recognized that among the factors that contribute to these effects, the following are the most important:

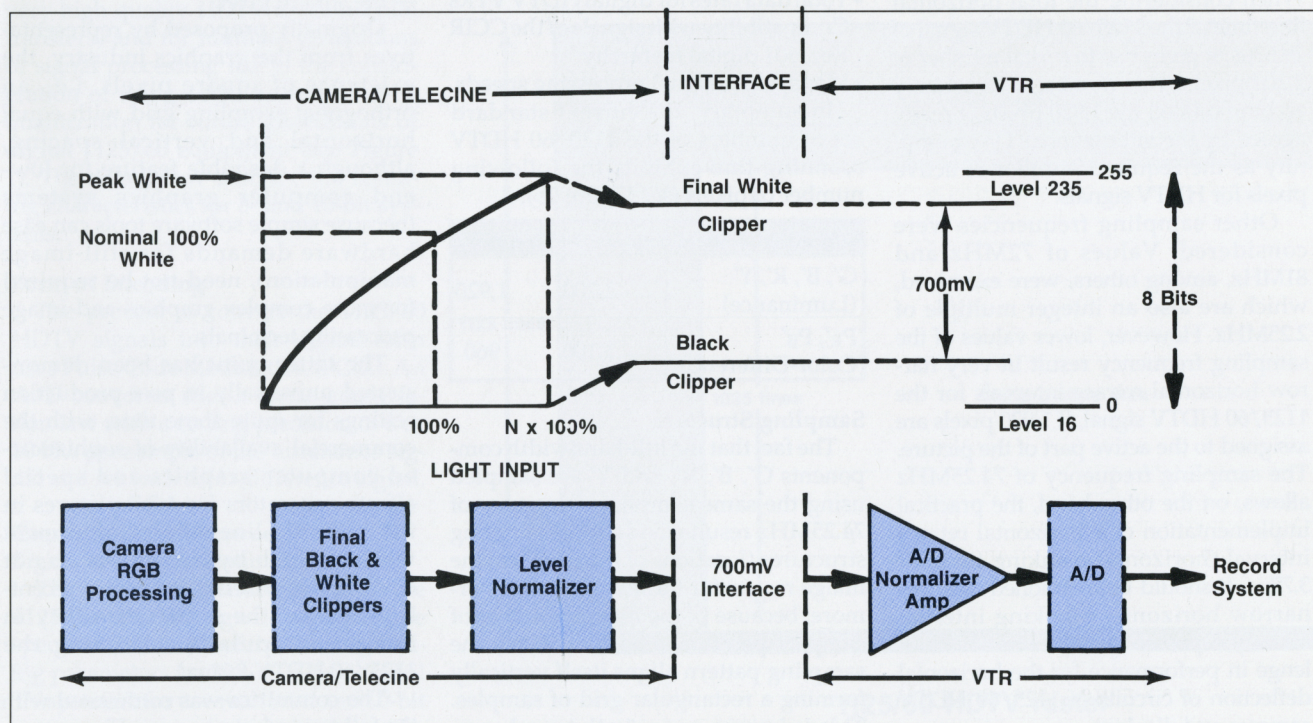


Figure 4. Considerations for HDTV camera-to-VTR (peak video excursion) interface.

- Bandwidth limitation of component analog signals (most noticeably, the ringing of color-difference signals, and the compound effects of filtering in tandem A/D and D/A conversions).
- Amplitude clipping of the HDTV signals due to the finite dynamic range of the quantization process.
- The use of digital blanking in repeated analog-digital-analog conversions.

This was an area of study which benefited immensely from the painful experiences gained by the post-production industry throughout the 8-9 years of work with digital 4:2:2 equipment.

In order to accommodate the needs of spatial filtering during post-production operations (with its possible recurrent reduction of active picture area), as well as to consider the aforementioned limitations, the following technical guidelines have been recommended:

- A Production or Origination Aperture for the HDTV studio digital signal, defining an active area of 1,920 pixels by 1,035 lines of video information, will be produced by HDTV cameras, digital HDTV tape recorders, and computer generated pictures that conform to the 1125/60 standard. This video information should be stored and processed by all HDTV studio equipment.

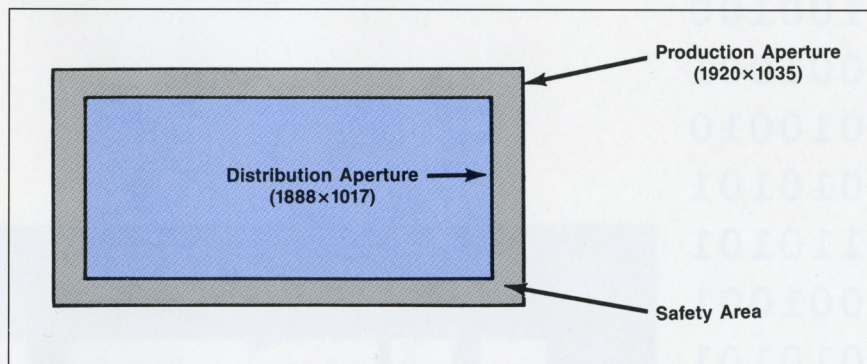


Figure 5. Production and distribution apertures.

- A Distribution Aperture is defined by 1,888 pixels by 1,017 lines (Figure 5). This video area could result from the various degrees of spatial filtering and/or methods for handling the horizontal and vertical edges of the picture under normal post-production processing.
 - The definition of this distribution aperture implies the existence of a Safety Area that can accommodate, if required, various amounts of picture transient effects. This area is defined by 16 samples on each side and 9 lines at both the top and bottom of the production aperture. This gives rise to a possible minimum picture area of 1,888 pixels by 1,017 lines, within the production aperture, whose quality is guaranteed for final distribution.
- It is proposed that a final edited

HDTV master that fits anywhere within this safety area will be in compliance with the standard.

FILTERING CHARACTERISTICS

Spectral characteristics of the component video signals must be restricted to eliminate aliasing. Digitizing Y' , P_B' , and P_R' components (with bandwidths of 30MHz and 15MHz, respectively, as defined in SMPTE-240M), can be achieved by using filters whose insertion loss characteristics recommended for 4:2:2 signals. The details of such filters were put forth in the recommendations of the SMPTE Ad Hoc Group.

THE BIT-PARALLEL DIGITAL INTERFACE

The transport protocol as well as the mechanical and physical configuration of a bit-parallel digital interface for 1125/60 were studied both by the members of the SMPTE Ad Hoc Group and by the Broadcast Television Association of Japan.

The present consideration is that the signals on this interface can be transmitted using a multi-core shield-type balanced cable for distances of up to 20

- Ancillary data
- Identification codes
- Clock signal (tolerances, jitter, etc.)
- Electrical interface characteristics

Mechanical

- Mechanical characteristics of connector and cable assemblies.
- Drawing diagrams for the connector and cable.

CONCLUSION

Although an all-digital description might be written for a video related data stream used within a computer workstation or all-digital manipulation environment, this cannot be true for HDTV. The HDTV production standard must completely describe the primary attributes of the studio signal origination — the electrical signal parameter set produced by a totally analog optical-electro transformation by the HDTV camera. It must also encompass the electro-optical transformation at the far end of the system — the analog HDTV display.

Elements of these signal parameter sets may indeed be described by a digital representation, but some fundamental analog representations are still central to the standard. SMPTE-240M is an HDTV production standard that describes completely the needed parameters that circumscribe signal origination, interface and display.

Once the signal has been generated by the camera, the signal can be treated exclusively in digital or analog form, or, as is more usual within a total system, in a hybrid digital and analog manner.

The recent major work of SMPTE in detailing a complete digital representation of the 1125/60 SMPTE-240M standard effects a complete description of the production standard. This has been established in a way that will enable manufacturers to design both digital and analog equipments, and will allow users to assemble total systems that are configured as completely digital, analog, or hybrid analog/digital.

The pace of digital implementation of HDTV studio equipment is already vigorous. Digital HD VTRs, digital production switchers, digital video effects, digital frame recorders, digital image enhancement in cameras are already emerging and are almost all in conformance with the proposals currently under study by SMPTE. This confident commitment by many manufacturers is, in itself, a significant testimony to the exemplary work of the SMPTE in forging solid, all-encompassing studio standards for HDTV.

meters. A single connector has been adopted for the interface, which has a total of 93 contacts (three contacts for the shield-type twisted wires; two contacts for the balanced signal pair and one contact assigned to the shield) and is capable of transmitting:

- Y' , P_R' , P_B' at 8 bits (22:11:11 member of Rec. 601 hierarchy)
 - Y' , P_R' , P_B' at 10 bits (22:11:11)
 - R' , G' , B' at 8 bits (22:22:22)
 - R' , G' , B' at 10 bits (22:22:22)
- (plus a signal pair for clock information at 74.25MHz).

The final standard includes specs for the following interface parameters:

Signal

- Video digital data
- Digital blanking characteristics
- Timing reference codes

0010001	0001001	1001011
1001010	0010101	1001001
0011100	0101010	0010100
1010101	1125/60	1010011
0100100	1111010	1001010
0101010	1010010	0101110
1010000	1001001	1010010
1011110	1001010	1000100
1100101	0010101	0111101
0010010	0100101	1101010
1001001	0111010	1010010
0010010	1010101	1125/60
1001011	0101000	1010010
1001001	1110101	1001010
0010100	0101010	0101001
1125/60	1110101	0101001
1001010	0101010	0100100
1010101	1010101	1001001
0101110	1011101	0010010
1010010	0101101	1010101
1001010	0010001	0110101
0111101	0000100	0001001
1101010	1125/60	0010101
1010010	1001010	0101010
1010010	0011100	0101000
1001010	1010101	1111010
0101001	0100100	1010010
0101001	0101010	1001001
0100100	1010000	0100101
1001001	1011110	0010101
1125/60	1100101	0100101
0010010	0100100	0111010
1001010	1001001	1010101
0110101	0010010	1001010



c/o Rice Communications
33 South Delaware Ave., Suite 202
Yardley, PA 19067
215-321-4250